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Vegetation and Soil Comparisons Among Three Areas: Mowed, Relict, and Moderately Grazed

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VEGETATION AND SOIL COMPARISONS AMONG THREE AREAS: MOWED, RELICT, AND MODERATELY GRAZED

being

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THESIS ABSTRACT

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The purpose of this study was to determine effects of mowing and grazing on native vegetation of grasslands compared to a relict area. Three areas were selected in relation to past treatment: relict, mowed and moderately grazed. On each area two sites were selected, a breaks site and a limy upland site. The relict area used for study is located on southeast quarter of S6, T14S, R18W, mowed on southeast quarter of S35, T13S, R19W, and moderately grazed on southeast quarter of S36, T13S, R19W; all near Hays, Kansas in Ellis County.

Vegetation of the three areas was sampled by the point transect method to determine percent composition, basal cover and frequency. A total of 400 sets or 4,000 points was taken at random. Yields were obtained by clipping eight square meter plots on each site.

Soils of the three areas were analyzed for texture, pH and organic matter. Analysis was done to determine the amount of variation between the sites. Texture was determined by the Bouyoucos hydrometer method, pH by the Beckman pH meter and organic matter by wet digestion method.

Dominant grasses on the relict breaks site were side-oats grama, big bluestem and little bluestem which made up 90.22 percent of the vegetation. The mowed breaks site supported the same dominant grasses as the relict site but little bluestem almost doubled in composition. Dominants on the grazed breaks site were side-oats grama with 30.10 percent and hairy grama with 19.97 percent composition. Tall grasses decreased and shortgrasses increased due to grazing on the breaks sites.

Total basal cover for the relict, mowed, and grazed breaks sites was 21.51, 24.15 and 16.50 percent, respectively. Mowing increased basal cover but grazing decreased basal cover. Total forage yields on the relict, mowed and moderately grazed breaks sites was 2187.8, 1899.3 and 1975.0 pounds per acre, respectively.

Dominant grass on the relict limy upland was big bluestem but the dominant of mowed and grazed sites was side-oats grama. Big bluestem decreased and blue grama increased as a result of mowing and grazing on the limy upland sites. Just a trace of buffalo grass was found on the relict site but was abundant on the mowed and grazed sites.

Total basal cover on the relict, mowed and grazed limy upland sites was 20.20, 30.25, and 28.82 percent, respectively. Total forage yields on the relict, mowed and grazed limy upland sites was 2403.4, 2278.4 and 2141.8 pounds per acre, respectively.

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INTRODUCTION

If proper management of grasslands for sustained productivity is to be maintained, careful studies must be made regarding effects of various treatments, such as mowing or grazing. Many studies have been made to determine effects of intensities of grazing and of mowing on yield; however, little work had been done concerning the effects of mowing on botanical composition of vegetation, especially on the prairies of western Kansas.

Effect of mowing on vegetation may be quite different from the effect of grazing. With mowing, all vegetation is clipped at the same height at the same time, but with grazing animals the vegetation is not completely defoliated though occasionally whole plants or portions are uprooted. Furthermore, grazing by animals is largely selective, so that more palatable species of grasses and forbs are more seriously affected than less palatable ones and, in addition, effects of trampling must be considered. Botanical composition of grazed pastures is partially due to the above effect of grazing animals.

The purpose of this study is to determine effects of mowing and grazing on native vegetation of grasslands compared to a relict grassland area. Factors measured were yield, composition, basal cover, and frequency of vegetation.

RELATED STUDIES

In their monograph of the prairie, Weaver and Fitzpatrick (1934) stated: "Practically all of the prairies have been mowed annually, some for a period of more than fifty years. Removal of the plant cover after maturity has no harmful effect upon the vegetation. After mowing is done close to the soil surface, there still remains 2.5 to 3 inches of unmowed stubble with dead basal leaves, among which accumulates fallen debris during 'hay making' as well as the late autumnal growth. Undoubtedly the removal of the plants does have an effect not only upon the quantity of organic material that would ultimately return to the soil but also upon the density and composition of plant cover." Mulch in annually mowed prairies may have a dry weight of 50-225 gm. per square meter on uplands (Weaver and Rowland, 1952).

Experiments over a period of only three to five years by Weaver and Fitzpatrick (1934) have shown that the accumulation of debris retards growth in the spring. Soil warms more slowly since it does not receive the usual insolation. Not only is there an actual diminution of basal cover with accumulated mulch, but also certain of the smaller and earlier species are greatly handicapped in growth and tend to disappear (Weaver and Rowland, 1952).

Effects of intensity and frequency of clipping on yield and vigor of various range grasses, in general, show that yield and vigor decrease as frequency and/or intensity of mowing or clipping are increased (Albertson, et al., 1953). Other studies that support this statement are (Watson, Chang and Wilson, 1962; Newell and Keim, 1947; Stoddart, 1946; Cook, et al., 1958; Weaver, 1930; Aldous, 1930).

Under frequent clipping or long continued grazing and trampling the native bluestems and most other prairie grasses disappear resulting in a reduction in yields (Weaver and Hougen, 1939).

Tomanek (1948) found that, under favorable growing conditions, frequent harvesting at moderate heights sometimes causes production of greater herbage yields than does a single clipping at the end of the growing season.

Daubenmire and Colwell (1942) found that overgrazing in the Palouse area of eastern Washington resulted in a considerable reduction in plant cover and the replacement of the tall dominant perennial species by weedy annuals.

Clipping at 30-day intervals severely retarded root and top production of all species of grass while clipping at 15-day intervals caused a reduction of 41 percent in top growth when clipped at height of two inches. In other words,

the shorter the interval between mowings the greater the damage to the vegetation (Carter and Law, 1948).

Weaver and Darland (1947), in measuring loss of vigor of various grasses due to clipping, found that dry weight of weakened plants was 32 to 84 percent less than that of plants which had good to fair vigor. Furthermore, they found that width of new leaves of non-vigorous plants averaged 15 to 40 percent narrower.

Marked quantitative responses of root, rhizome, and top growth of various grasses (blue grass, red top, fescue, and timothy) grown under field and greenhouse conditions are correlated with cutting treatments (Graber, 1931). Not only did the amount of subterranean growth and total weight of top growth ultimately tend to vary inversely with the frequence of defoliation, but reduced growth sometimes occurred for several months following excessive defoliation. Productive capacity of grasses is not only dependent upon adequate supplies of available nutrients and moisture combined with favorable light and temperature conditions, but also upon the food reserves of the plant. Organic food reserves have a significant ecological relationship, especially with reference to the flora of grasslands.

McCarty and Price (1942), working with two grasses and two forbs on summer range in central Utah, found that plants clipped once early and at, or near, the close of the season maintained a greater forage yield and had greater carbohydrate reserves than plants clipped during the middle of the season when reproduction was in progress. They concluded that the critical periods in the life cycle of the plants studied are the active reproductive period and the forepart of the normal carbohydrate storage period following seed ripening.

According to Bukey and Weaver (1939) food reserves are reduced more by frequent and close clippings than by a single clipping or less close clipping.

Studying Ladino white clover, Moran et al. (1953) found that defoliation caused a depletion of carbohydrate reserves in both stolons and roots. Depletion was greater when the carbohydrate level was high than when it was low. Stored carbohydrate amounts was affected by height and frequency of defoliation.

Conard and Arthaud (1957), found that, on a Nebraska prairie, time of mowing had the greatest effect on the composition of the prairie. Early mowing had the greatest effect while late mowing had the least effect. Composition changed from primarily tall grasses to a mixture of tall

and mid grasses. Only one grass showed a great reduction in composition --- prairie dropseed, which was reduced 60, 34, and 19 percent under early,midseason, and late cutting, respectively. Most forbs did not show a reduction in composition but did show a decrease in vigor and size of stem.

Not all species of grasses suffer to the same extent from cutting or grazing. Species possessing a prostrate growth habit, a well developed root system, or a large bulk of rhizomes, and hence a large store of underground reserves, are relatively resistant to close and frequent defoliation. Under ordinary circumstances prostrate growth prevents a complete defoliation and leaves sufficient foliage intact for the maintenance of a high level of reserves (Weimann, 1955).

METHODS OF STUDY

Study areas were selected in the fall of 1961 after vegetation had become dormant and the communities had their characteristic contrasting colors. Three areas were selected in relation to past treatment: relict, mowed, and moderately grazed area. On each area two sites were selected, a breaks site and a limy upland site as described by the Soil Conservation Range Guide Classification (1961).

Vegetation of the three areas was sampled by the point transect method (Levy and Madden, 1933). The point frame used in this study was 24 inches long and had 10 points two inches apart.

A total of 400 sets or 4,000 points was taken at random during the summer on each site and recorded on field data sheets. The field data sheets were then totaled and percent composition, basal cover, and frequency calculated.

Yields were obtained by clipping eight square-meter plots. Clipping plots were randomly located by throwing the square and clipping the vegetation inside the square. Grasses were separated according to individual species but all forbs were put into only one bag; vegetation was air dried, weighed in grams and converted to pounds per acre. The plots were clipped the last of September near the end

of the growing season but before the vegetation reached full dormancy.

A statistical comparison of the vegetative composition on the different areas was calculated by using the students T-test (Dixon and Massey, 1957). Using the dominant species of grass, a calculation was made to determine how close to the mean the vegetation was sampled on each site. Forbs were listed and their relative abundance was recorded on each site.

Authority used for plant names was Hitchcock (1950) and Rydberg (1932).

Breaks sites occur on nearly level to steeply rolling lands having dominantly smooth, often rocky, slopes but occasionally with some broken or dissected areas. Slopes range from one to 30 percent, averaging 12 to 15 percent, with a soil depth usually less than 20 inches.

Limy uplands have loam, silt loam, or silty clay loam surface soils and subsoils, moderate permeability with a high water holding capacity. Most of the soils are weakly to strongly calcareous to the surface with strongly calcareous subsoils. Limy upland soils are well drained and of high fertility, with a soil depth usually over 20 inches. The slope for each site was determined with a transit.

Soils of the three areas were analyzed for texture, pH, and organic matter. An analysis was made to determine how much variation there was between the sites. Samples of soil were collected with a geotome at depth intervals of 6, 12, 24, 36, 48 and 60 inches. A total of three samples was taken on each site and averaged.

Texture was determined by the Bouyoucos hydrometer method (Bouyoucos, 1936). Hydrogen ion concentration or pH was determined on each soil sample by using the Beckman pH meter. Organic matter content in the top six inches of soil was determined by the wet digestion method (Schollenberger, 1947).

DESCRIPTION AND LOCATION OF STUDY AREAS

The areas investigated in this study are near Hays, Kansas, in the Mixed Prairie Association. Vegetation is primarily shortgrass, intermixed with small amounts of mid and tall grasses (Albertson, 1937). Annual precipitation and temperatures are extremely variable. Normal precipitation is 22.95 inches, but the extremes ranged from 43.34 inches in 1951 to 9.21 inches in 1956 (Weather Bureau, U.S. Department of Commerce, 1962). Annual precipitation during the study period (1962) was 23.09 inches, just slightly above the longtime average. Most precipitation comes in spring, summer and fall in the form of rain, and snowfall adds to the annual precipitation but commonly less than 12 inches of snow falls in a year. Winter temperatures are often less than -10°F. several days each winter. Summers are usually hot, dry and windy. Daily maximum temperatures in excess of 100°F. are common. Due to xeric summer conditions much of the vegetation often becomes semidormant or completely dormant. Dormancy is usually broken when early fall precipitation occurs.

Elevation in the study vicinity is approximately 2,150 feet, but due to the rolling topography a change in

elevation can occur quite rapidly. Drainage from the study areas is toward the east since all the sites were located on an east-facing slope.

The relict area selected for study is located three miles southwest of Hays, Kansas on the southeast quarter of S6, T14S, R18W. This area has been maintained as a relict area by Fort Hays Kansas State College for the past 60 years so that future naturalists would have an area for comparing soils and vegetation of other areas to this undisturbed grassland.

The mowed area for study was selected three miles west of Hays, Kansas on the southeast quarter of S35, T13S, R19W, on land belonging to Frank B. Pfeifer. Mr. Pfeifer stated that in the past 40 years the study area had been used strictly for a hay meadow and had never been grazed. The area is mowed only once a year, usually between the 16th and 31st of July.

The moderately grazed area is located 2.5 miles southwest of Hays, Kansas, on the southeast quarter of S36, T13S, R19W. Fort Hays State College farm regulates grazing on the area and has followed a moderate grazing program for the past 40 years.

RESULTS

Soils

An analysis of soils showed little variation among soils of the three areas. Since there was little variation among soils of the same site, one description will be given for the breaks site and one for the limy upland site.

Breaks Site

The Breaks site has a layer of soil six to twelve inches in depth, underlaid with flaggy pieces of Fort Hays limestone. Limestone fragments are present on the surface of the soil but increase in size as depth increases. The presence of the many fragments resulting in good drainage make the soils on the breaks site slightly basic.

Organic matter tests showed that the greatest amount of organic matter in the top six inches on the breaks site was on the moderate grazed area with 16.5 tons per acre. The mowed area was second with 15.0 tons per acre and relict area last with 7.5 tons. A soil description by depths in inches follows:

0-6 10y R2/2m, gravelly clay loam texture, moderate to strong fine medium granular structure; many fine and medium sized roots; gravel up to one inch in diameter; strongly calcareous, pH of 7.3.

6-12 10y R3/3m, texture gravelly clay loam, structure moderate to strong fine medium granular, many large pieces of gravel, increasing in size at bottom of layer, strongly calcareous, pH of 7.8.

12- Fort Hays limestone layer.

Limy Upland Site

Soils of this site have a depth of 20 inches or more, with a few fine fragments of limestone on the surface but increasing in size as depth increases. Soils are well drained and of high fertility. Limestone particles on the surface make this soil basic to the surface.

Tests for organic matter showed that the grazed area had 20 tons per acre, the mowed area 17.5 tons per acre, and the relict area 13.5 tons per acre. Most of the organic matter on the relict area was on top of the soil. The following is a description of the soil by de_th in inches:

0-6 10y R2/2, texture silty clay loam, moderate, medium granular structure, many fine medium roots, few fine fragments of limestone gravel, strongly calcareous, pH of 7.4.

6-12 R3.5/2, texture silty clay loam, moderate, medium granular structure, several fine medium roots, strongly calcareous, pH of 7.9.

12-24 10y R4/2, texture heavy silty clay loam, moderate, medium and fine subangular blocky structure, many fine medium roots, few worm castings, strongly calcareous, pH of 8.1.

24-36 10y R4/2, texture silty clay loam, weak to moderate, medium, subangular blocky structure, few fine roots, strongly calcareous, pH of 8.2.

36-48 10y R3/3, texture silty clay loam, weak, coarse, prismatic structure, segregated lime on ped faces and old root channels present, few fine roots, strongly calcareous, pH of 8.3.

48-60 10y R3/2.5, texture silty clay loam, weak, coarse, prismatic, porous structure, many limestone fragments, few fine roots, strongly calcareous, pH of 8.3.

Breaks Site Vegetation

Breaks sites are generally located on areas where soil is thin and dominant vegetation is taller grasses (Fig.1). As described by the Soil Conservation Range Guide Classification (1961), principal decreaser grasses on the site are little bluestem (Andropogon scoparius), big bluestem (Andropogon gerardi), switchgrass (Panicum virgatum), and Indiangrass (Sorghastrum nutans), which make up to 60 percent of the climax composition, with perennial forbs and other grasses accounting for the remainder. Principal increaser grasses are side-oats grama (Bouteloua curtipendula), blue grama (Bouteloua gracilis), hairy grama (Bouteloua hirsuta), and buffalo grass (Buchloe dactyloides). Common invaders are annuals.

Relict Breaks Site

Dominant grasses on the relict breaks site were side-oats grama, big bluestem and little bluestem, which made up 90.22 percent of the vegetation present (Table 1). Decreasers comprised 61.18 percent of vegetation, while increasers had only 38.54 percent. The remaining vegetation was common invader annual grasses. Total basal cover of vegetation was 21.51 percent.

Big bluestem had the highest frequency of 50.25 percent

Figure 1. East slope of the mowed breaks site indicating the general type of topography of the breaks sites of the three areas.

Table 1. Average percent basal cover, composition and frequency of grasses on the breaks site of the relict area.

Species	Percent basal cover	Percent composition	Percent frequency
Side-oats grama	7.22	33.56	50.00
Big bluestem	6.22	28.91	50.25
Little bluestem	5.97	27.75	29.75
Hairy grama	0.85	3.94	5.75
Indian grass	0.82	3.83	5.75
Switch grass	0.15	0.70	1.25
Blue grama	0.12	0.58	1.00
Hairy dropseed	0.10	0.47	1.00
Tall dropseed	0.03	0.13	0.25
Purple three-awn	0.03	0.13	0.25
Total	21.51	100.00	

while side-oats grama was second with 50.00 percent. Little bluestem, also a dominant, had a frequency of only 29.75 percent. Little bluestem was found in bunches and big bluestem and side-oats grama were evenly distributed. Numerous other grasses were present but of little significance.

Yields on the relict site were produced almost entirely from tall grasses. Shortgrasses produced only 7.0 pounds of the total 1864.6 pounds of grass yield (Table 2). Big bluestem, the dominant grass on relict area, produced 711.8 pounds of forage per acre. Little bluestem with 553.6 pounds, and side-oats grama with 509.2 pounds, together produced over half the total grass yield. Forbs contributed 323.2 pounds of the total vegetative yield of 2187.8 pounds per acre.

Mowed Breaks Site

Tall grasses and midgrasses were more common on the mowed breaks site than shortgrasses. Dominant grasses of the area were little bluestem, which made up 51.80 percent of the vegetation, and side-oats grama with 20.99 percent of the composition (Table 3). Composition of big bluestem was 16.96 percent. Decreaser grasses made up 70.21 percent of the vegetation, while increasers made up only 29.68 percent. A small amount of Virginia wildrye (Elymus virginicus) was found on the site, along with numerous other grasses of little

Table 2. Yield in pounds per acre on the breaks sites of the relict, mowed and moderately grazed areas.

Species	Relict	Mowed	Grazed
Side-oats grama	509.2	154.3	266.2
Big bluestem	711.8	485.2	230.5
Blue grama	----	2.3	71.1
Little bluestem	553.6	903.6	375.6
Hairy dropseed	11.1	24.6	4.9
Sand dropseed	----	----	3.2
Western wheatgrass	----	1.6	----
Hairy grama	11.9	2.2	173.1
Switchgrass	----	----	40.6
Indian grass	67.0	9.9	----
Purple three-awn	----	----	4.2
Total grass yields	1864.6	1583.7	1169.4
Total forbs	323.2	315.6	805.6
Total vegetation	2187.8	1899.3	1975.0

Table 3. Average percent basal cover, composition and frequency of grasses in the breaks site of the mowed area.

Species	Percent basal cover	Percent composition	Percent frequency
Little bluestem	12.52	51.80	52.30
Side-oats grama	5.07	20.99	36.00
Big bluestem	4.10	16.96	29.80
Hairy grama	0.95	3.93	6.50
Blue grama	0.95	3.93	6.50
Indian grass	0.27	1.14	2.80
Hairy dropseed	0.15	0.62	1.50
Switch grass	0.07	0.31	0.80
Virginia wildrye	0.02	0.11	0.30
Buffalo grass	0.05	0.21	0.50
Total	24.15	100.00	

significance.

Little bluestem was found in 52.30 percent of the samples (Table 3). Bunches of little bluestem were much larger in diameter than those on the relict breaks site. Side-oats grama and big bluestem had 36.00 and 29.80 percent frequency, respectively. Blue grama and hairy grama were found in about five percent of the samples taken.

Total basal cover for the site was 24.15 percent or 2.54 percent difference higher than relict breaks site. Mowing caused a decrease in basal cover of big bluestem and Indiangrass but blue grama and hairy grama increased slightly in basal cover. Little bluestem increased in basal cover as a result of mowing.

Yields of shortgrasses increased slightly on the mowed area but the greatest bulk of grass yields came from tall and midgrasses. On the mowed breaks site 29.1 pounds per acre was produced by shortgrasses and 1552.6 pounds from tall and midgrasses (Table 2). Side-oats grama and big bluestem decreased in production on the mowed site but little bluestem almost doubled its yield on the mowed site compared to the relict breaks site. Forbs produced 306.6 pounds per acre, about the same as forb yield on the relict area.

Moderate Grazed Breaks Site

Shortgrasses showed a marked increase while the tall grasses showed a decrease in composition on the moderately grazed site. Co-dominant grasses of the site were side-oats grama with 30.10 percent of composition, hairy grama with 19.97 percent, little bluestem with 18.91 percent and blue grama with 18.31 percent (Table 4). Decreaser grasses made up 30.06 percent of vegetation or only half as much as the decreasers on the relict site. Increaser grasses comprised 69.74 percent of vegetation, or twice as much as on the relict site.

Side-oats grama had the highest frequency with 37.50 percent, and was evenly distributed throughout the area. Hairy grama and blue grama were much more widely scattered under moderate grazing as indicated by increased frequency compared to the relict area.

Total basal cover for the grazed breaks site was 16.50 percent, 5.01 percent less than the relict and 7.55 percent less than the mowed breaks site. All decreaser species were reduced in basal cover but blue grama and hairy grama increased. Grazing usually causes increased basal cover unless grazing is heavy, but on this breaks site there was a decrease.

Table 4. Average percent basal cover, composition, and frequency of grasses on the breaks site of the moderate grazed area.

Species	Percent basal cover	Percent composition	Percent frequency
Side-oats grama	4.97	30.10	37.50
Hairy grama	3.30	19.97	25.75
Little bluestem	3.12	18.91	22.50
Blue grama	3.02	18.31	23.00
Big bluestem	1.57	9.53	14.50
Hairy dropseed	0.17	1.06	1.25
Switch grass	0.15	0.91	1.50
Indian grass	0.10	0.61	0.75
Buffalo grass	0.05	0.30	0.50
Purple three-awn	0.05	0.30	0.50
Total	16.50	100.00	

Shortgrasses furnished a larger portion of the yield on the grazed breaks site compared to the relict breaks site. Shortgrasses produced 257.1 pounds and tall grasses 912.3 pounds per acre of a total yield of 1169.4 pounds of grass forage. Forbs made up a large percent of the yield on the grazed site contributing 805.6 pounds or 41 percent of the total yield. Greatest total yield was harvested from the relict area followed in order by the grazed and mowed sites.

Composition of individual species on the breaks sites was compared using students T-test. A significant difference in composition occurred as long as a species of the relict area was used in the comparison (Table 5). When the comparison was between species of the grazed and mowed sites there was no significant difference between side-oats grama and blue grama but all other comparisons were highly significant. Analysis showed a significant difference between relict and mowed sites on species composition but total of decreaser and increaser species showed no difference.

Limy Upland Site Vegetation

Limy upland sites usually have a deep soil that is calcareous to the surface with conditions suitable for the

Table 5. Comparisons of differences of composition of dominant species among three vegetation habitats using the students T-test.

Comparisons between areas	Bcu[1]	Age	Bgr	Asc	Bhi
Breaks Site					
Mowed and relict	12.57*[2]	11.95*	3.35*	24.05*	0.01
Mowed and grazed	9.11	7.43*	14.38	32.89*	16.04*
Grazed and relict	3.46*	19.38*	17.73*	8.84*	16.03*

Comparisons between areas	Bcu	Age	Bgr	Bda
Limy upland				
Mowed and relict	22.86*	43.96*	11.97*	12.32*
Mowed and grazed	7.02	0.01	8.70	1.80
Grazed and relict	29.88*	43.95*	3.27*	10.52*

1
Bcu--Bouteloua curtipendula
Age--Andropogon gerardi
Bgr--Bouteloua gracilis
Asc--Andropogon scoparius
Bhi--Bouteloua hirsuta
Bda--Buchloe dactyloides

2
Indicates a significant difference at the 99 percent level of probability.

growth of tall grasses (Figure 2). Such decreaser grasses as little bluestem, side-oats grama, big bluestem, switchgrass, and Indiangrass may make up to 50 percent of the vegetation of the climax composition, with perennial forbs and other grasses accounting for the remainder. Important increasers are blue grama, western wheatgrass (Agropyron smithii), sand dropseed (Sporobolus cryptandrus) and buffalo grass. Common invaders are windmill grass (Chloris verticillata) and annuals.

Relict Limy Upland Site

The relict upland site was dominated by tall and mid-grasses with a few shortgrasses intermixed. Grasses that were dominant were big bluestem with 49.50 percent and side-oats grama with 29.70 percent of the vegetation (Table 6). Blue grama, an increaser, comprised 13.90 percent of the vegetation. Decreaser grasses comprised 85.24 percent of vegetation and increasers 14.76 percent.

Big bluestem was the most abundant grass, with 59.50 percent frequency, and was evenly scattered throughout the area. Side-oats grama was second with 35.25 percent and blue grama was next with 15.75 percent. Remaining grasses were scattered. Total basal cover for the relict limy upland site was 20.20 percent.

Figure 2. East slope of the moderately grazed limy upland indicating the general type of topography found on the limy upland sites.

Table 6. Average percent basal cover, composition, and frequency of grasses on the limy upland site of the relict area.

Species	Percent basal cover	Percent composition	Percent frequency
Big bluestem	10.00	49.50	59.50
Side-oats grama	6.00	29.70	35.25
Blue grama	2.80	13.90	15.75
Little bluestem	1.07	5.31	6.00
Tall dropseed	0.10	0.49	1.00
Buffalo grass	0.10	0.49	1.00
Western wheatgrass	0.08	0.37	0.75
Switchgrass	0.05	0.24	0.50
Total	20.20	100.00	

Limy upland site yields from the relict area also consisted primarily of tall or midgrasses. Tall grasses produced 1654.6 pounds and shortgrasses 324.2 pounds of forage per acre (Table 7). The highest producing grass was big bluestem, with 928.5 pounds per acre, which together with side-oats grama furnished 64 percent of the total yield of grass. Forbs contributed 371.8 pounds to the total forage yield of 2403.4 pounds.

Mowed Limy Upland Site

Dominant species of the mowed site were side-oats grama and blue grama and together comprised 78.43 percent of the composition (Table 8). Side-oats grama was the most common grass occurring in 80.75 percent of the samples. Buffalo grass, big bluestem and western wheatgrass were all quite common but were unevenly distributed throughou. the area. Decreaser grasses comprised 58.27 percent of the composition and increaser grasses 39.59 percent.

Buffalo grass occurred in small islands on the site where the soil was heavier. Big bluestem was scattered throughout the site and was quite abundant in some favored locations, but comprised only 5.54 percent of the total vegetation. Little bluestem, a decreaser grass, occurred only in widely scattered bunches. Other grasses present

Table 7. Yields in pounds per acre on the limy upland sites of the relict, mowed and moderately grazed areas.

Species	Relict	Mowed	Grazed
Side-oats grama	617.1	1075.5	1284.8
Big bluestem	928.5	507.9	204.7
Blue grama	309.3	216.8	61.2
Buffalo grass	14.9	34.0	96.8
Tall dropseed	69.3	17.9	26.0
Sand dropseed	30.5	----	----
Hairy dropseed	----	----	8.9
Purple three-awn	8.9	7.0	53.0
Western wheatgrass	52.9	----	----
Total grass yield	2031.6	1859.1	1735.5
Total forb yield	371.8	419.3	405.3
Total vegetation	2403.4	2278.4	2141.8

Table 8. Average percent basal cover, composition, and frequency of grasses on the limy upland site of the mowed area.

Species	Percent basal cover	Percent composition	Percent frequency
Side-oats grama	15.90	52.56	80.75
Blue grama	7.80	25.78	48.75
Buffalo grass	3.87	12.81	24.50
Big bluestem	1.67	5.54	10.50
Purple three-awn	0.43	1.32	3.00
Western wheatgrass	0.24	0.82	2.50
Red three-awn	0.12	0.41	1.00
Sand dropseed	0.05	0.17	0.50
Little bluestem	0.05	0.17	0.50
Virginia wildrye	0.05	0.17	0.50
Tall dropseed	0.05	0.17	0.50
Hairy dropseed	0.02	0.08	0.25
Total	30.25	100.00	

were sand dropseed, Virginia wildrye, tall dropseed (Sporobolus asper) and hairy dropseed (Sporobolus pilosus).

Tall grasses decreased in basal cover as a result of mowing and shortgrasses increased. Tall dropseed, an increaser under grazing, decreased in basal cover with mowing. Purple three-awn increased as a result of mowing. Mowing increased total basal cover 10.50 percent compared to the relict limy upland site.

The dominant grass, according to yields, on the mowed site was side-oats grama with 1075.5 pounds of a total yield of grass of 1859.1 pounds per acre (Table 7). Big bluestem produced 507.9 pounds and the remainder was mainly shortgrass with 250.8 pounds. Yield of forbs was similar to the yield of the relict limy upland site.

Moderate Grazed Limy Upland Site

Side-oats grama was the most common grass of the moderately grazed site occurring in 85.50 percent of the samples (Table 9). Dominant grasses of the site were side-oats grama and blue grama, together comprising 76.75 percent of the composition. Buffalo grass was also quite common and made up 11.01 percent of the vegetation. Decreaser grasses furnished 65.13 percent of vegetation while increasers furnished 28.27 percent of composition.

Table 9. Average percent basal cover, composition, and frequency of grasses on the limy upland site of the moderate grazed area.

Species	Percent basal cover	Percent composition	Percent frequency
Side-oats grama	17.17	59.58	85.50
Blue grama	4.95	17.17	35.00
Buffalo grass	3.17	11.01	22.30
Big bluestem	1.60	5.55	10.00
Purple three-awn	1.45	5.03	10.80
Tall dropseed	0.22	0.78	2.30
Hairy dropseed	0.12	0.43	0.50
Little bluestem	0.05	0.18	0.30
Western wheatgrass	0.03	0.09	0.30
Hairy grama	0.03	0.09	0.30
Red three-awn	0.03	0.09	0.30
Total	28.82	100.00	

Little bluestem was not common on the site, but occurred only in scattered bunches. Tall dropseed occurred in small communities throughout the site but was not abundant, occurring in only 2.30 percent of the samples. Other grasses present were hairy dropseed, western wheatgrass and hairy grama.

Big bluestem and little bluestem decreased as a result of grazing until they made up only a small part of the total basal cover. Side-oats grama increased 11.17 percent in composition as compared to the relict site. Grazing increased total basal cover. Total basal cover for the moderately grazed limy upland site was 28.82 percent.

Yields on the grazed site were primarily from side-oats grama which produced 1284.8 pounds of forage of a total yield of 1735.5 pounds of grass (Table 2). Big bluestem produced 204.7 pounds and tall dropseed 26.0 pounds. Shortgrasses produced 157.0 pounds. Purple three-awn produced 53.0 pounds; an increase over the relict and mowed sites. Forbs produced 406.3 pounds of forage, about the same as on the other two sites. Total production for the grazed site was 261.6 pounds lower than the relict site.

Statistical analysis showed a highly significant difference between composition of common species when comparing the relict site to the grazed or mowed, but no

significant difference when grazed or mowed sites were compared with each other, except blue grama (Table 5).

Forbs

One forb found abundantly on the relict breaks site and not on the grazed site was lead plant (Amorpha canescens). A few scattered plants of lead plant were found on the mowed breaks site but were less vigorous. Stiff leaved goldenrod (Solidago rigida) and broom snakeweed (Gutierrezia sarothrae) increased under grazing and mowing (Table 10).

Broom snakeweed and western ragweed (Ambrosia psilostachya) increased markedly as a result of mowing and grazing on the limy upland site. The stiff leaved goldenrod was abundant on the mowed and grazed sites and the resinous skullcap (Scutellaria resinosa) was abundant on the mowed limy upland. Maxmilian's sunflower (Helianthus maxmiliani) was abundant on the relict and grazed sites but not on the mowed site (Table 11).

Table 10. Relative abundance[1] of forbs on the breaks sites of the three areas.

Species	Relict	Mowed	Grazed
Solidago rigida	C	A	A
Helianthus maxmiliani	C	D	D
Liatris punctata	C	C	A
Dalea enneandra	C	C	B
Arenaria texana	C	B	A
Thelesperma gracile	B	A	A
Morongia uncinata	A	A	C
Gutierrezia sarothrae	C	B	A
Yucca glauca	C	C	C
Houstonia angustifolia	C	A	A
Tetraneuris stenophylla	B	A	A
Oenothera serrulata	A	A	A
Cirsium undulatum	D	B	C
Petalostemon purpureum	B	C	A
Amorpha canescens	A	B	D
Dalea aurea	C	C	B
Scutellaria resinosa	B	A	A
Tragia ramosa	A	A	B
Aster multiflorus	A	C	A
Stenosiphon linifolius	A	C	A

Table 10 (Continued)

Species	Relict	Mowed	Grazed
Echinacea angustifolia	C	A	B
Psoralea tenuiflora	B	C	C
Opuntia macrorhiza	C	C	B
Aster arenosus	A	A	A
Polygala alba	C	C	B
Senecio plattensis	D	C	B
Astragalus mollissimus	C	C	B
Aster oblongifolius	B	D	B
Paronychia jamesii	C	B	A
Townsendia exscapa	D	C	A
Lesquerella ovalifolia	C	B	A

[1]
A-Abundant.
B-Scattered but not abundant.
C-Scarce.
D-Not present.

Table 11.[1] Relative abundance of forbs on the limy upland sites of the three areas.

Species	Relict	Mowed	Grazed
Liatris punctata	B	C	B
Scutellaria resinosa	B	A	B
Cirsium undulatum	B	A	B
Ratibida columnifera	C	B	C
Amorpha canescens	C	C	D
Aster multiflorus	A	B	B
Oenothera serrulata	B	B	B
Morongia uncinata	C	B	C
Helianthus annuus	D	C	C
Solidago rigida	D	A	B
Gutierrezia sarothrae	C	B	A
Polygala alba	C	C	B
Salvia pitcheri	D	C	C
Yucca glauca	C	B	B
Houstonia angustifolia	C	B	B
Aster oblongifolius	B	B	B
Aster arenosus	B	B	B
Echinacea angustifolia	D	C	C
Lactuca ludoviciana	C	B	B
Thelesperma gracile	C	C	C

Table 11. (Continued)

Species	Relict	Mowed	Grazed
Hymenopappus corymbosus	C	C	C
Sideranthus spinulosus	D	D	C
Callirrhoe involucrata	C	B	B
Astragalus mollissimus	D	C	C
Lesquerella ovalifolia	D	C	C

[1]
A-Abundant.
B-Scattered but not abundant.
C-Scarce.
D-Not present.

SUMMARY

This study was initiated to determine whether mowing had an effect on vegetation similar to effects of moderate grazing on mixed prairie near Hays, Kansas. Three areas were selected for study; relict, mowed, and moderately grazed. On each area two sites or communities were studied: breaks site and limy upland. Results of the mowed and grazed area were compared to results on the relict area.

Data were collected by using the point transect method of analysis. A total of 24,000 point samples were taken; 4,000 on each of the six sites. Soil samples were taken to determine the amount of variation between sites.

Dominant grasses on the relict breaks site were side-oats grama, big bluestem and little bluestem, which made up 90.22 percent of the vegetation. The mowed breaks site supported the same dominant grasses as the relict site, but little bluestem almost doubled in composition and big bluestem was reduced about half in composition. As a result of grazing on the breaks site, shortgrasses increased. Dominants on the grazed breaks site were side-oats grama with 30.10 percent composition, and hairy grama with 19.97 percent. Tall grasses decreased due to grazing and short-grasses increased on the breaks sites.

The dominant grass on the relict limy upland site was big bluestem but the dominant of both mowed and grazed sites was side-oats grama. Big bluestem, the dominant on the relict site, decreased markedly under mowing and grazing. Blue grama increased in composition on mowed site but the highest increase was on the grazed, compared to the relict site. Little bluestem nearly disappeared on the mowed and grazed limy upland. Just a trace of buffalo grass was found on the relict site, but the mowed site had 12.81 percent and the grazed site 11.01 percent. Purple three-awn increased 1.32 percent on mowed site and 5.03 percent on the grazed site compared to relict area which had no purple three-awn.

Total basal cover for the relict, mowed, and grazed breaks sites was 21.51, 24.15 and 16.50, respectively. Mowing increased basal cover 2.64 percent, but grazing decreased basal cover 5.01 percent from the relict cover.

Total basal cover on the relict, mowed, and grazed limy upland sites was 20.20, 30.25, and 28.82 percent, respectively. Mowing increased basal cover 10.25 percent and grazing increased cover 8.62 percent.

Total forage yields on the relict, mowed, and grazed breaks sites was 2187.8, 1899.3, and 1975.0 pounds per acre, respectively. Forbs increased in yield from 323.2 pounds

on the grazed site. The relict breaks site yielded more than either the mowed and grazed sites.

Forage yields for the relict, mowed, and grazed limy upland sites was 2403.4, 2278.4, and 2141.8 pounds per acre, respectively. Big bluestem produced the highest yield on the relict limy upland site, with 928.5 pounds, but on the grazed site, side-oats grama, with 1075.5 pounds was highest. Forb yields for the three sites were similar. The relict limy upland site yielded more than either the mowed and grazed sites.

Lead plant was found abundantly on relict breaks site and not on the grazed site. Only a few scattered plants of lead plant were present on the mowed breaks site. Stiff leaved goldenrod and broom snakeweed both increased under grazing and mowing. Western ragweed increased to a large degree on the grazed limy upland site as compared to relict area.

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APPENDIX

APPENDIX A

Scientific Name	Common Name
Grasses	
Agropyron smithii Rydb.	Western wheatgrass
Andropogon gerardi Vitman	Big bluestem
Andropogon scoparius Michx.	Little bluestem
Aristida longiseta Steud.	Red three-awn
Aristida purpurea Nutt.	Purple three-awn
Bouteloua curtipendula (Michx.) Torr.	Side-oats grama
Bouteloua gracilis (H.B.K.) Lag. & Steud.	Blue grama
Bouteloua hirsuta Lag.	Hairy grama
Buchloe dactyloides (Nutt.) Engelm.	Buffalo grass
Chloris verticillata Nutt.	Windmill grass
Elymus virginicus L.	Virginia wildrye
Panicum virgatum L.	Switchgrass
Sorghastrum nutans (L.) Nash	Indiangrass
Sporobolus asper (Michx.) Kunth	Tall dropseed
Sporobolus cryptandrus (Torr.) A. Gray	Sand dropse d
Sporobolus asper var. pilosus (Vasey) Hitchc.	Hairy dropseed
Forbs	
Ambrosia psilostachya D. C.	Western ragweed
Amorpha canescens Pursh.	Lead plant
Arenaria texana Robins	Texas sandwort
Aster arenosus Blake	Baby white aster
Aster multiflorus Ait.	Many flowered aster
Aster oblongifolius Nutt.	Aromatic aster
Astragalus mollissimus Torr.	Wooly loco
Callirrhoe involucrata (T.&G.) Gray	Purple poppy mallow
Cirsium undulatum (Nutt.) Spreng.	Wavyleaf thistle

Appendix A (continued)

Dalea aurea Nutt.	Silktop dalea
Dalea enneandra Nutt.	Nineanther dalea
Echinacea angustifolia D.C.	Black samson
Gutierrezia sarothrae (Pursh.) Britt. & Rusby	Broom snakeweed
Helianthus annuus L.	Common sunflower
Helianthus maxmilliani Schrad.	Maxmilians sunflower
Houstonia angustifolia Michx.	Narrow leaved houstonia
Hymenopappus corymbosus T.&G.	Corymbed hymenopappus
Lactuca ludoviciana (Nutt.) D.C.	Florida lettuce
Lesquerella ovalifolia Rydb.	Bladderpod
Liatris punctata Hook.	Dotter gayfeather
Morongia uncinata Britton	Sensitive briar
Oenothera serrulata Nutt.	Serrate leaved evening primrose
Opuntia macrorhiza Engelm.	Pricklypear cactus
Paronychia jamesii T.& G.	James nailwort
Petalostemon purpureum (Vent). Rydb	Purple prairie clover
Polygala alba Nutt.	White milkwort
Psoralea tenuiflora Pursh.	Wild alfalfa
Ratibida columnifera (Nutt.) Woot.& Standl.	Prairie coneflower
Salvia pitcheri Torr.	Pitcher sage
Scutellaria resinosa Torr.	Resinous skullcap
Senecio plattensis Nutt.	Prairie ragwort
Sideranthus spinulosus (Pursh.) Sweet	Spiny sideranthus
Solidago rigida L.	Stiff Leaved goldenrod
Stenosiphon linifolius (Nutt.) Britt.	Tall eveningprimrose
Tetraneuris stenophylla Rydb.	Stemless tetraneuris
Thelesperma gracile (Torr.) Gray	Slender greenthread
Townsendia exscapa (Rich.) Porter	Stemless townsendia
Tragia ramosa Torr.	Stinging spurge
Yucca glauca Nutt.	Small soapweed